International Standard

ISO 18488

Polyethylene (PE) materials for piping systems — Determination of strain hardening modulus in relation to slow crack growth — Test method

Matériaux polyéthylène (PE) pour systèmes de canalisations — Détermination du module d'écrouissage en relation avec la propagation lente de fissures — Méthode d'essai

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 5, *General properties of pipes, fittings and valves of plastic materials and their accessories — Test methods and basic specifications*.

This second edition cancels and replaces the first edition (ISO 18488:2015), which has been technically revised.

The main changes are as follows:

— the definition for strain hardening modulus, $<G_p>$, has been improved;

— the definitions that are also in ISO 527-1 have been removed from this document;

— an improved depiction of L in Figure 1;

— the gripping distance in Table 1 has been clarified;

— the tolerance for the gauge length, l_0, has been increased;

— regrind from PE products has been added in 6.2 to align with the product standards (e.g. ISO 4437-2 and ISO 4437-3);

— reference to ISO 293 for compression moulding has been added;

— the description of the measurement of the thickness, h, and width, b_1, have been clarified;

— the explanations of the data analysis (Clause 8) and the strain hardening behaviour and the Neo-Hookean constitutive model (Annex A) have been revised.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Resistance to slow crack growth of polyethylene materials is related in general to the lifetime of the material and thus, the lifetime of polyethylene products, e.g. pipes and fittings. The slow crack growth behaviour of a polyethylene material can be regarded as a combination of resistance to deformation of the crystalline phase (manifested as yield stress) and the amorphous phase (entangled chains and tie molecules) as reported by Kramer and Brown.[2],[3],[5],[6] The resistance to disentanglement of polymer chains in the amorphous phase of a polymer structure upon application of constant load will determine its resistance against slow crack growth.

The strain hardening modulus of polyethylene material is a measure of the resistance to disentanglement of the entangled chains and tie molecules of this polymer and is an intrinsic property. The strain hardening modulus of polyethylene is obtained from a “true stress vs. draw ratio” curve above the natural draw ratio. The “true stress vs. draw ratio” curve of a compression moulded sheet is relatively easily obtained using a tensile test apparatus equipped with an appropriate extensometer. The test time for measuring the strain hardening modulus is a consequence of the speed of tensile testing and is therefore constant for all measurements and independent of the slow crack growth property of the tested material itself.

The strain hardening modulus value allows differentiation between polyethylene materials. It has been demonstrated that the strain hardening modulus is sensitive to structural parameters of polyethylene [9],[10] and corresponds very well with several environmental stress cracking test methods for polyethylene, such as environmental stress cracking resistance (ESCR),[7] Pennsylvania notch test (PENT),[8] full-notch creep test (FNCT),[4] cracked round bar test (CRB) and notched pipe test (NPT)[11].

Polyethylene (PE) materials for piping systems — Determination of strain hardening modulus in relation to slow crack growth — Test method

1 Scope

This document specifies a method for the determination of the strain hardening modulus, which is used as a measure for the resistance to slow crack growth of polyethylene.

This document specifies how to obtain a strain hardening modulus measurement from "true stress vs. draw ratio" curves on compression moulded samples. Details of the necessary equipment, precision and sample preparation for the generation of data are given.

This document provides a method that is valid for all types of polyethylene, independent from the manufacturing technology, comonomer or catalyst type used for pipes and fittings applications.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 293, *Plastics — Compression moulding of test specimens of thermoplastic materials*

ISO 527-1, *Plastics — Determination of tensile properties — Part 1: General principles*

ISO 7500-1, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*

ISO 9513, *Metallic materials — Calibration of extensometer systems used in uniaxial testing*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 527-1 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
length
l
distance between the gauge marks on the central part of the test specimen at any given moment

Note 1 to entry: Length is expressed in millimetres (mm).